Extensions to the Gaussian Model of Ground Clutter in Dual-Polarized Weather Radar

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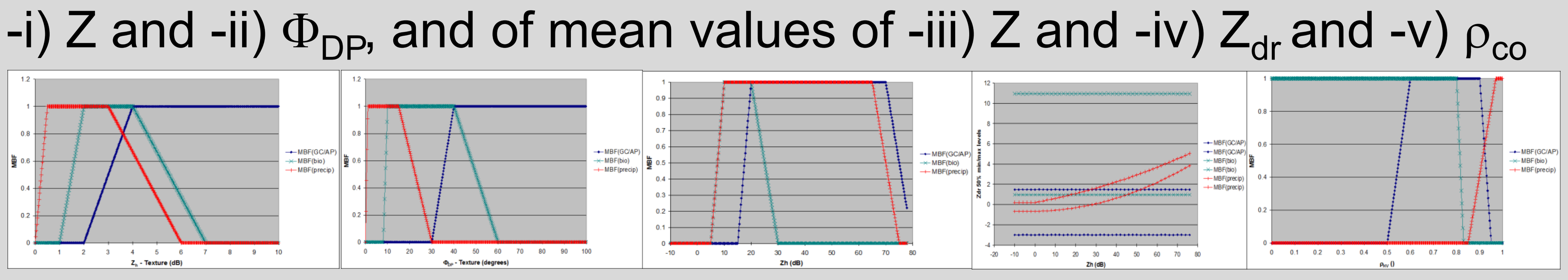
I. Gaussian model (GM) and ground clutter (GC)

- ❑ in Doppler weather radar, complex antenna voltages from Rayleigh scatterers of precipitation and from thermal noise are distributed in **bi-variate Gaussian** (Bringi, Chandrasekar, 2001; 1986)
- ❑ Gaussian power spectrum of **GC** echo (v_D =0, σ_D~0); few assumptions about ground properties.
- ❑ **GM** can be applied to each receiver channel H and V, or combined.
- ❑ **GM** is a model of echo data. Needs input from model(s) of scatterers.
- ❑ Known models exist for hydrometeors (Rayleigh) and thermal noise.
- ❑ **GC?**

II. Empirical knowledge of GC echo features

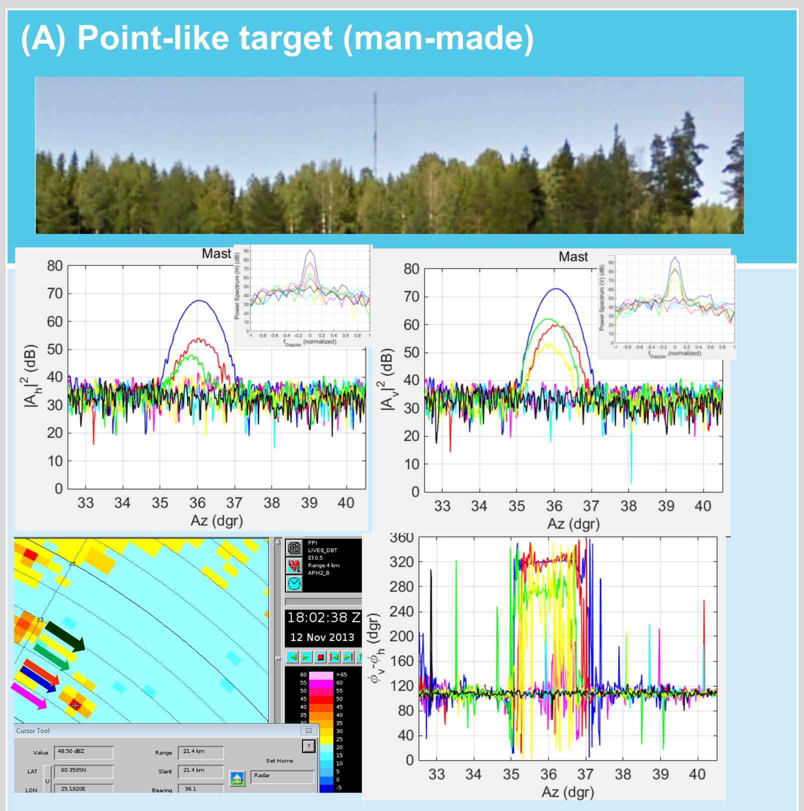
- ❑ Zrnic et al. 2005: co-polar correlations in **GC** echo
  ("..no attempt..to tie our measurements to the physical properties of ground objects")
- ❑ JPOLE (Ryzhkov et al. 2005): fuzzy method of spatial textures of -i) Z and -ii) Φ_{DP}, and of mean values of -iii) Z and -iv) Z_{dr} and -v) ρ_{co}



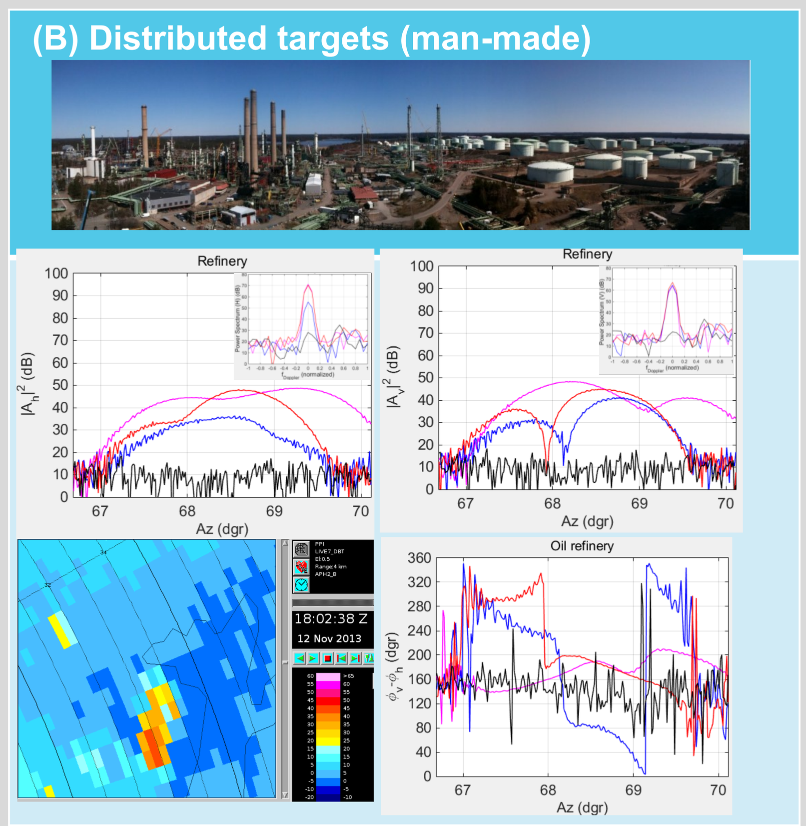
- ❑ Gourley et al. 2007: spatial textures (variability) of -i) Φ_{DP} and of -ii) Z_{dr} and mean value of -iii) ρ_{co}
- ❑ Hubbert et al. 2009: in addition, clutter phase alignment CPA, SPIN-Z
- ❑ Hubbert et al. 2009: models of RaM(~**GM**), RiM(~**GM+DC**), MRM(~RiM +leaves). RiM ok in terms of CPA for a particular data set.
- ❑ Does RiM describe base band data, generally? Is **GC** = **GM+DC?**

III. Dual-polarization base band data $\{(I,Q)_h,(I,Q)_v\}$ from various types of GC

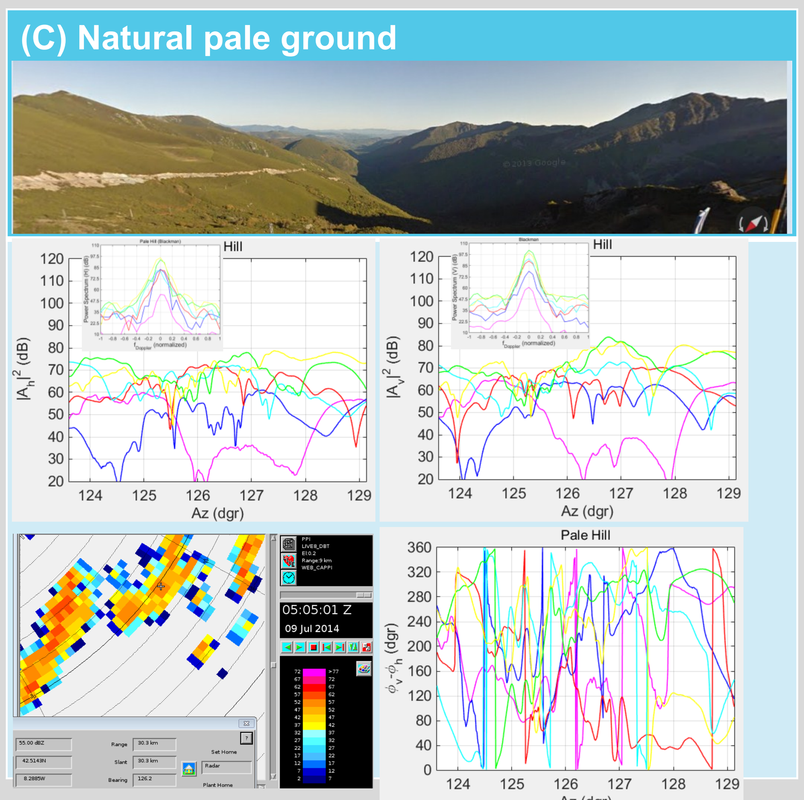
(A) Point-like target (man-made)



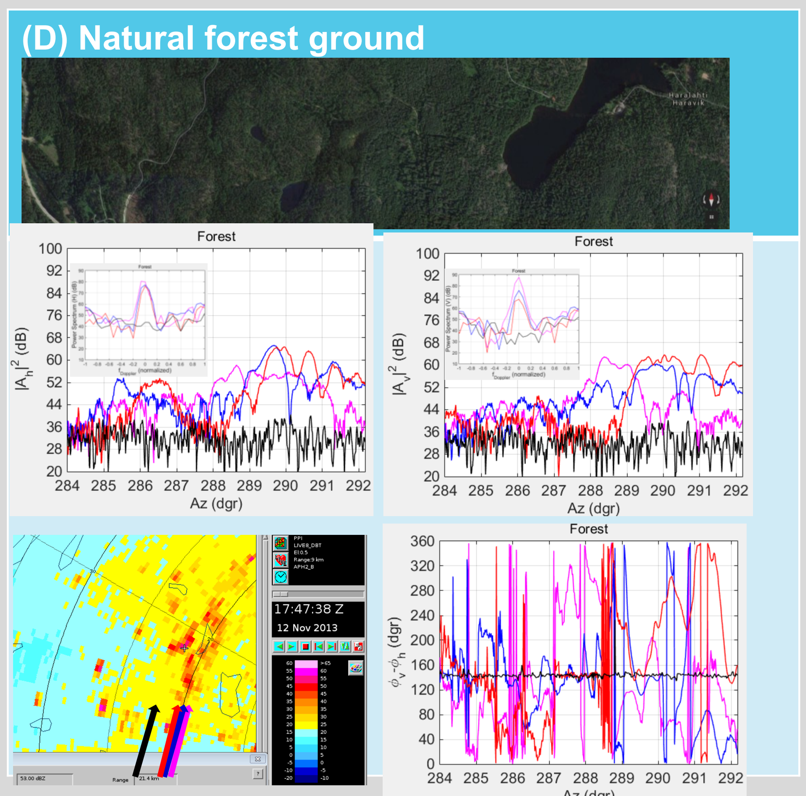
(B) Distributed targets (man-made)



(C) Natural pale ground



(D) Natural forest ground

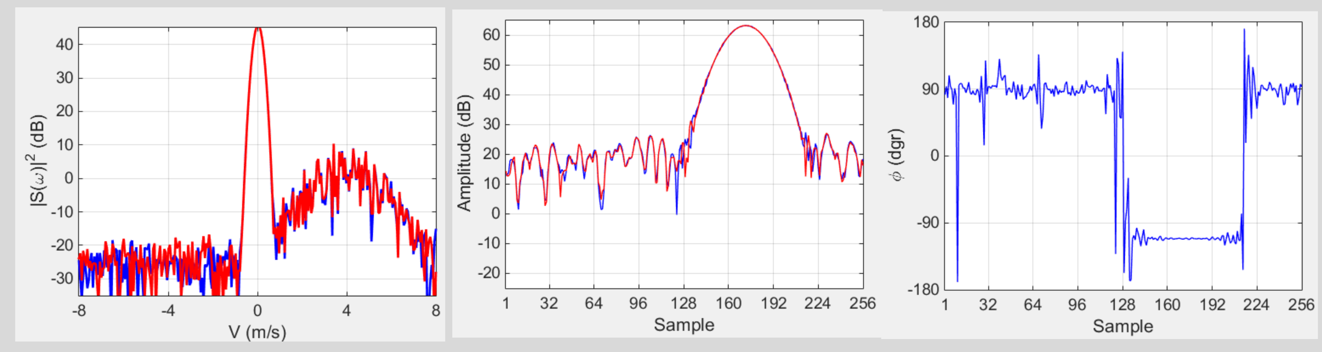


- ❑ (A): distinct point-like **GC** targets: constant (arbitrary) differential phase
  (B,C,D) extended **GC** targets: variable differential phases and relative amplitudes
  ←→ coherent superposition of echoes from many fixed **GC** targets.
- ❑ For point-like **GC,** the **GM** appears ok while ambiguous due to narrow spectral width. High co-polar correlation possible between H and V echo.

IV. Extension of GM into variably sized (N_{clt}) sets of GM point-like spatially distributed targets

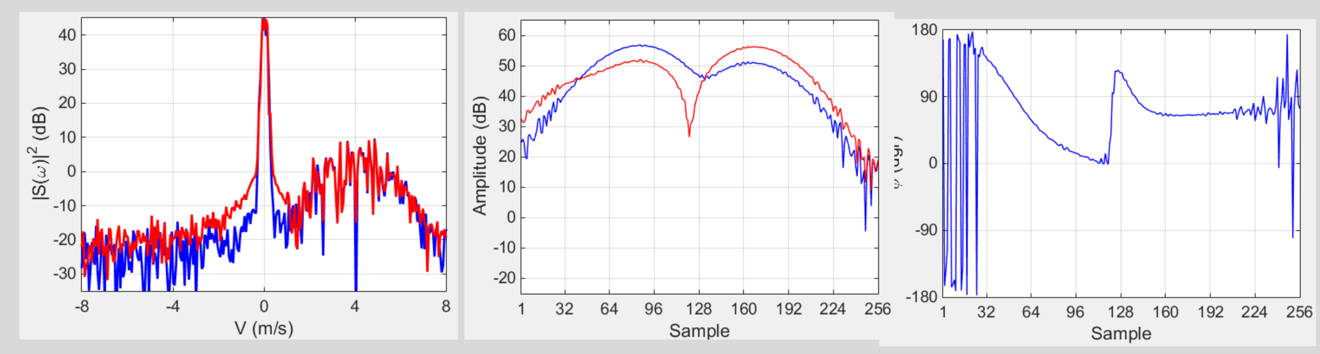
- ❑ Analogous to the "RaM"/"RiM" models of Hubbert et al. 2009.
- ❑ Do not describe **GC** as homogenous feature. Let the power scale free.
- ❑ Instead, interpret the **GC** echo either as an apparent point target

N_{clt}=1: **GM** (Bringi and Chandrasekar, 1986) for a single ground target, or



(MatLab)

N_{clt}>1 as extended ground clutter of spatially distributed rough surfaces (Long,2001) modeled as multiple **GM**(v_D =0, σ_D~0) targets.



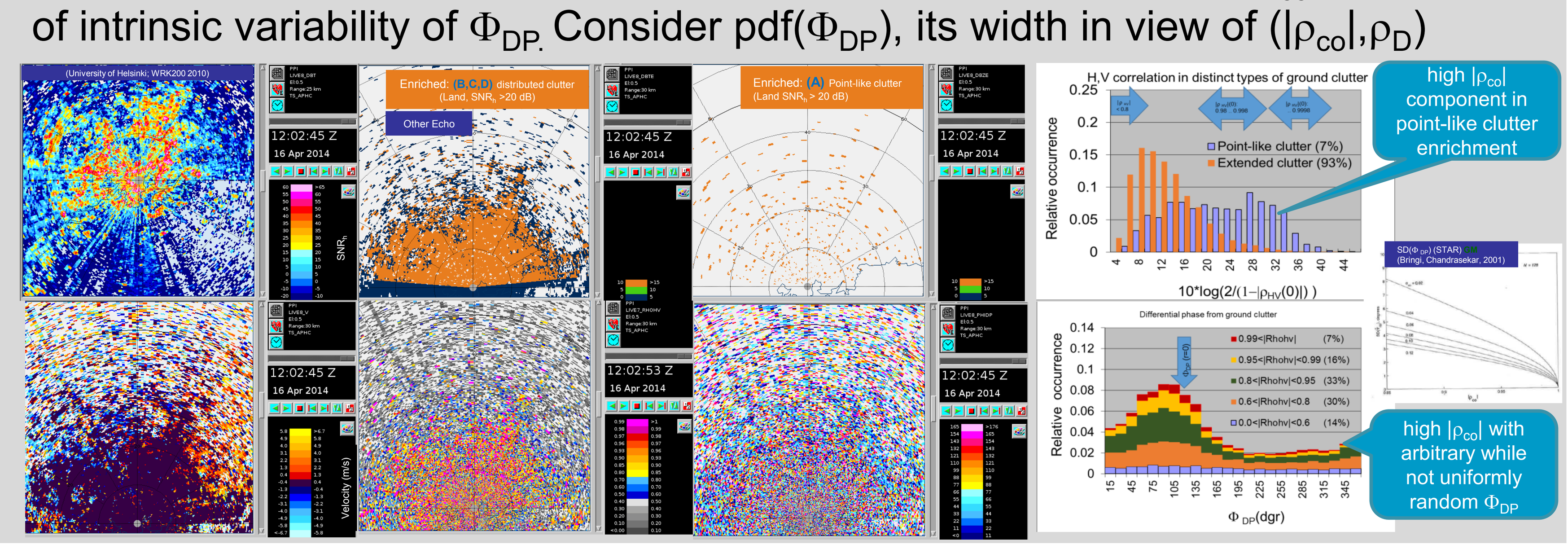
(MatLab)

- ❑ specific features in **GC** echo get explained as effects of superposition;
- ❑ the sub-structured model of **GC** seems describing the variable features of dual-polarization base band data $\{(I,Q)_h,(I,Q)_v\}$;

➔ a footing for generalized quantitative model of **GC** in dual-polarization

V. Does it work?

- ❑ consider echo from areas of fair weather in urban environment, SNR_h >10 dB.
- ❑ define 'point-like' **(A)** enriched sample as gates with $P_{h,v}$/<$P_{h,v}$> >20 dB where <..> is the local mean, max echo gates excluded. Then consider $|\rho_{co}|$ as measure of intrinsic variability of Φ_{DP}. Consider pdf(Φ_{DP}), its width in view of ($|\rho_{co}|$,ρ_D)



VI. Conclusions

- ✓ There is a rich feature set in the base band data **$\{(I,Q)_h,(I,Q)_v\}$** acquired from echoes of **GC**, by dual-polarization Doppler weather radar, within the approximately Gaussian power spectra. These feature information appear partially hidden in the moment estimators which are averaged data.
- ✓ A hypothesis of homogenous **GC** appears too rigid. Common sense suggests that distinct types of **GC** can be distinguished, confirmed by data.
- ✓ As 1st model extension, we may resolve the cases of **point-like GC** and of **extended GC** (as superposition of point-like targets), case-by-case.
- ✓ Such sub-divisions may turn a consistent model of the dual-polarization base band data **$\{(I,Q)_h,(I,Q)_v\}$**, thus providing a basis for quantitative understanding dual-polarization features in the **GC** echo component.
- ✓ Prominent uses: ground clutter mitigation, identification of clutter targets as signal.

References

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